US006512882B1

(12) United States Patent
Teunissen

(10) Patent No.: **US 6,512,882 B1**
(45) Date of Patent: **Jan. 28, 2003**

(54) **METHOD OF STORING DIGITAL AUDIO AND/OR VIDEO PROGRAMS COMPRESSED ON THE BASIS OF GROUPS OF PICTURES (GOPS) ON A MEDIUM WITH IMMEDIATE JUMPING BETWEEN GROUPS THROUGH CO-STORAGE OF TRANSPORT STREAM PACKETS AND POINTER INFORMATION, A METHOD FOR READING SUCH INFORMATION, AND A DEVICE FOR STORING AND/OR READING SUCH INFORMATION**

(75) Inventor: **Cornelis Teunissen**, Eindhoven (NL)

(73) Assignee: **Koninklijke Philips Electronics N.V.**, Eindhoven (NL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/307,159**

(22) Filed: **May 7, 1999**

(30) **Foreign Application Priority Data**

May 8, 1998 (EP) 98201509

(51) Int. Cl.^{7} **H04N 5/91**
(52) U.S. Cl. **386/70**; 386/68; 386/95; 386/125
(58) Field of Search 386/46, 95, 83, 386/125–126, 70, 111, 109; 360/39; 348/726; 725/50, 54; H04N 5/91

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,535,008 A	*	7/1996	Yamahishi et al.	386/109
5,596,564 A	*	1/1997	Fukushima et al.	386/125
5,619,337 A	*	4/1997	Naimpally	386/83
5,684,773 A	*	11/1997	Hayashi	369/59
5,701,386 A		12/1997	Yoneyama	386/909
5,909,257 A	*	6/1999	Ohishi et al.	348/726
6,160,954 A	*	12/2000	Ogawa	386/111
6,169,843 B1	*	1/2001	Lenihan et al.	386/46

FOREIGN PATENT DOCUMENTS

EP	0676895 A2	10/1995	....	H04N/5/926
EP	0712256 A2	5/1996	....	H04N/9/804
EP	0910087 A2	4/1999	....	G11B/27/34
WO	WO9407332	3/1994	....	H04N/5/92

* cited by examiner

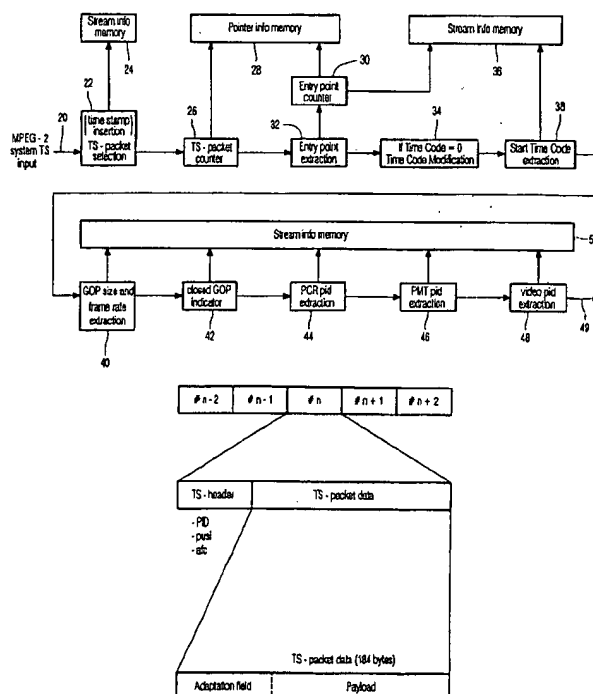*Primary Examiner*—Vincent Boccio
(74) *Attorney, Agent, or Firm*—Michael E. Balk

(57) **ABSTRACT**

Digital audio and/or video programs that have been compressed on the basis of groups of pictures (GOPs) are recorded on a medium that allows immediate jumping between groups through co-storage of Transport Stream packets and pointer information. In particular, coexistently with the storing, successive pointers are derived in realtime from a primary Transport Stream that collectively point to data packets in a reconstructed Transport Stream which contains entry points. These pointers are stored at predetermined locations on the medium.
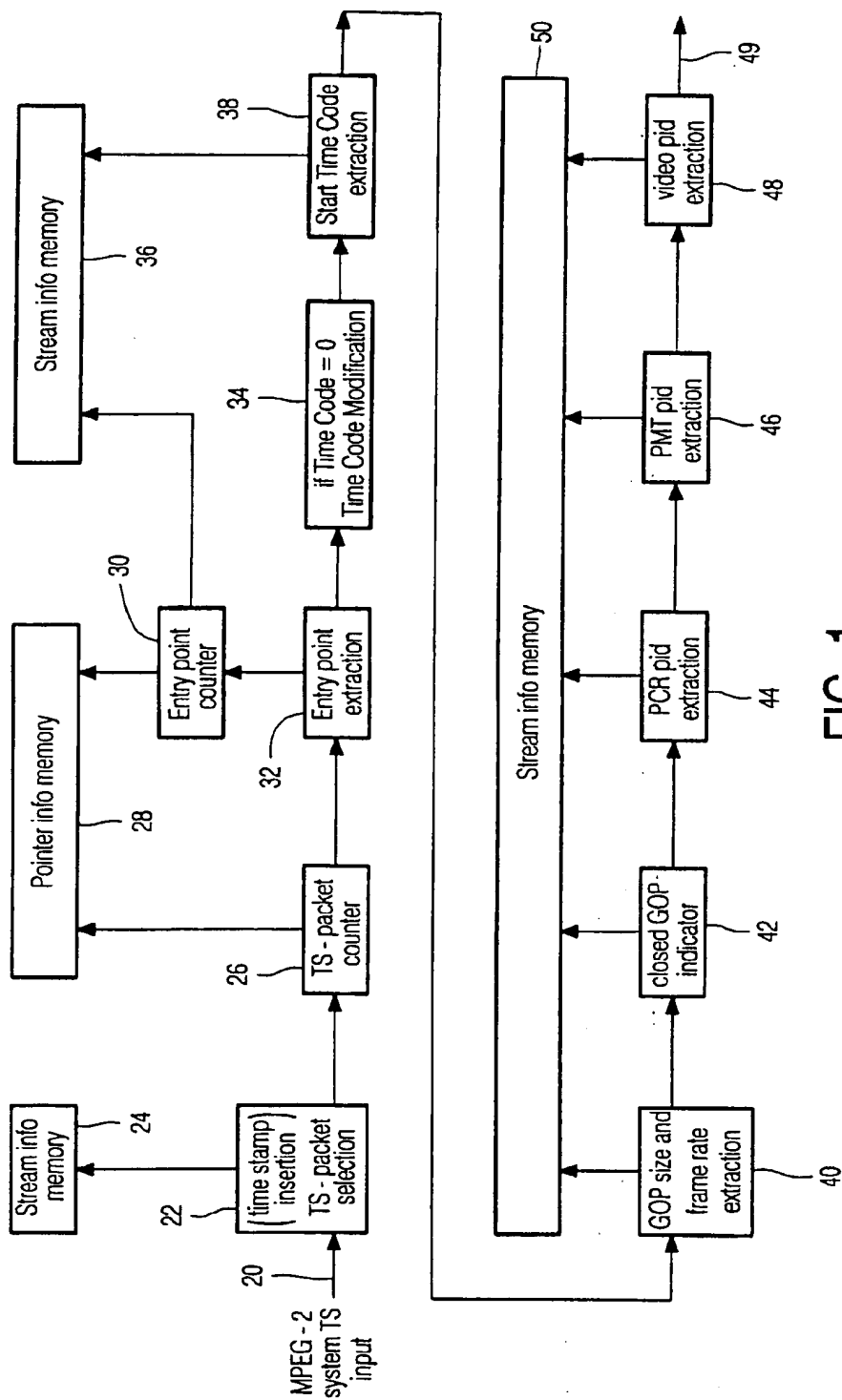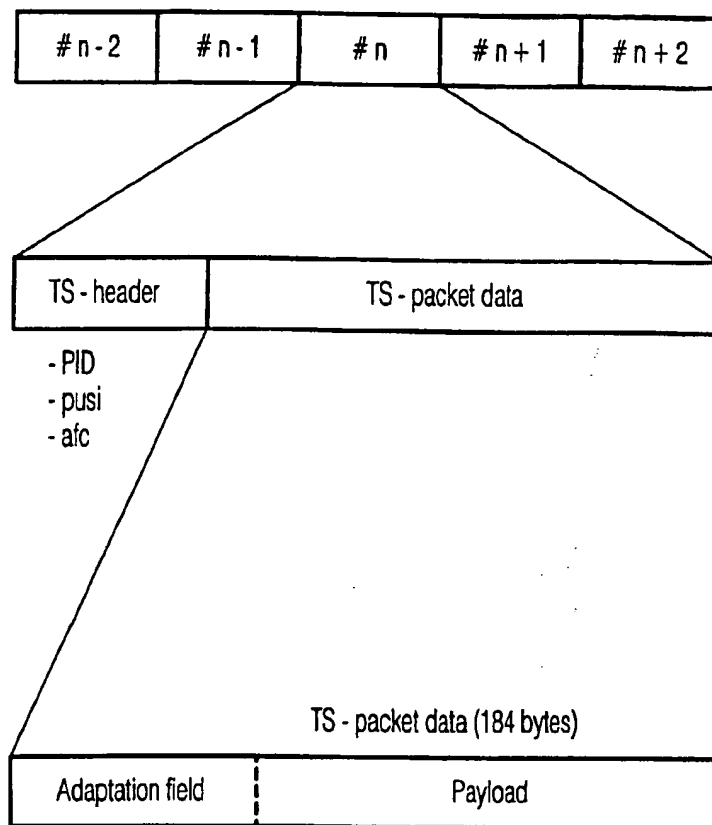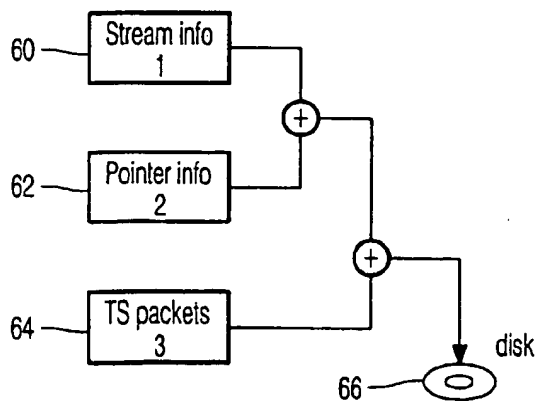
17 Claims, 4 Drawing Sheets

FIG. 1

| #n-2 | #n-1 | #n | #n+1 | #n+2 |

| TS - header | TS - packet data |

- PID
- pusi
- afc

TS - packet data (184 bytes)

| Adaptation field | Payload |

transport stream

FIG. 2

60 — Stream info 1

62 — Pointer info 2

64 — TS packets 3

66 — disk

stored structure

FIG. 3

Control unit — 80

- set speed
- set unit play duration (I - only / n GOP s) ?
- set start position
- display elapsed time
- retrieve pointer information
- retrieve stream information
- go fo logical byte positon (entry point)
- play (retrieve TS)
- stop
- ....

92 — disk ctr

74 — pointer info memory

76 — stream info memory

70 — disk

DEMUX

72 — TS

82 — extract Time Code

84
if closed - GOP ≠ 1 and play NGOP's
replace first B - frame packets'
with Null packets
if closed - GOP ≠ 1 (or play I - only)
update continuity counter
update temporal veference
set broken link to 1

94

86
if speed ≠ 1
replace TS packets'
≠ videopid
≠ PCR pid
≠ PMT pid
≠ PAT pid (0)
with Null packets'
Modify PTS, DTS, PCR

96

88
if time stamps = 1
reconstruct Time Base
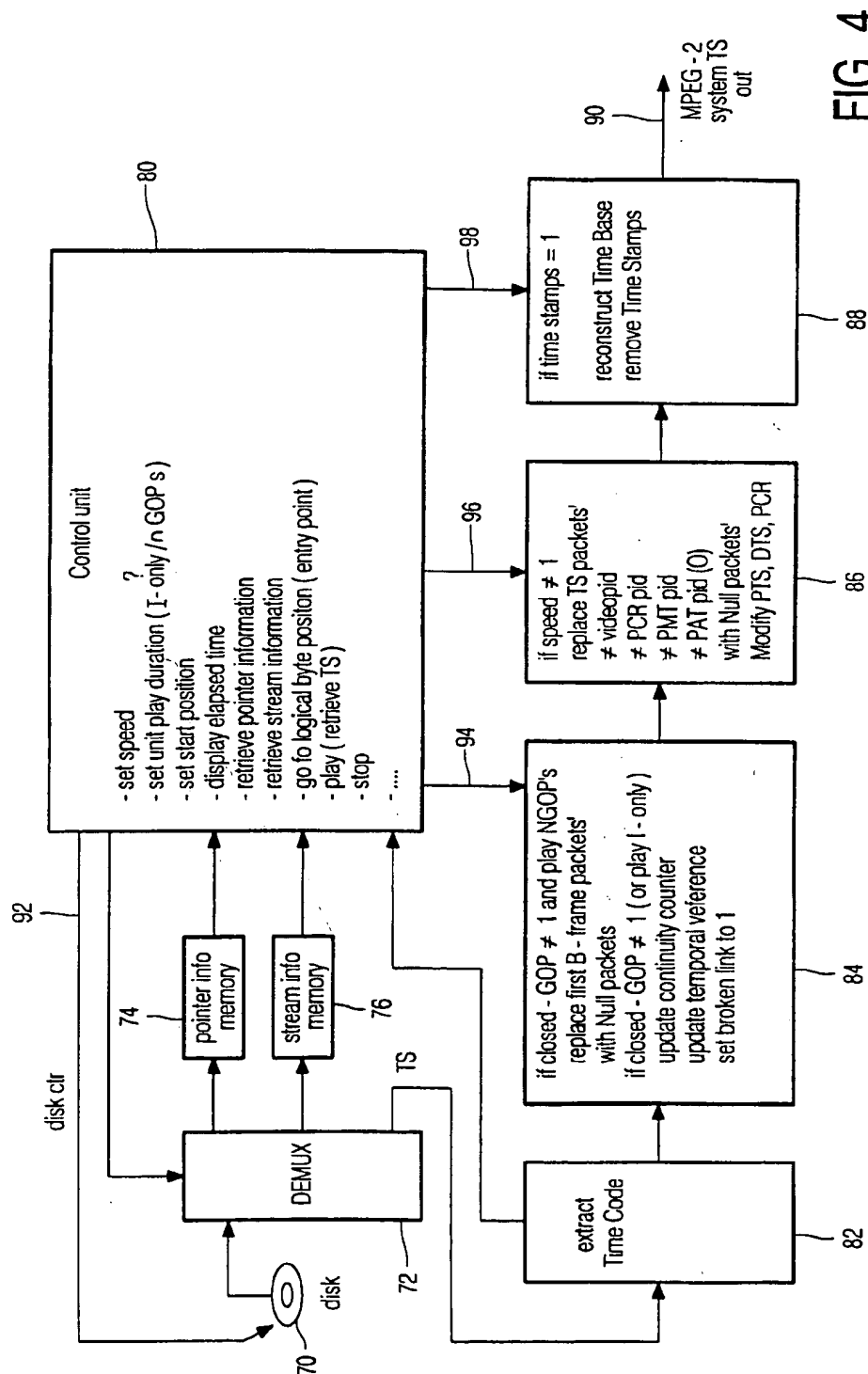remove Time Stamps

98

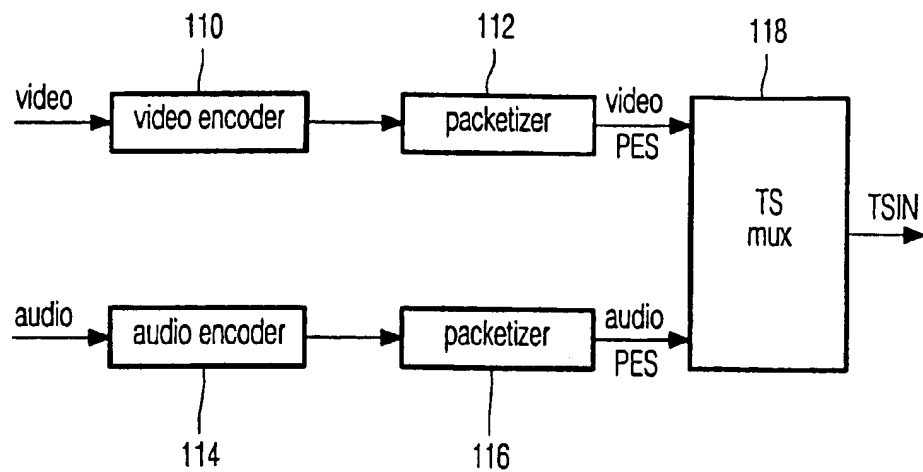90 — MPEG - 2 system TS out
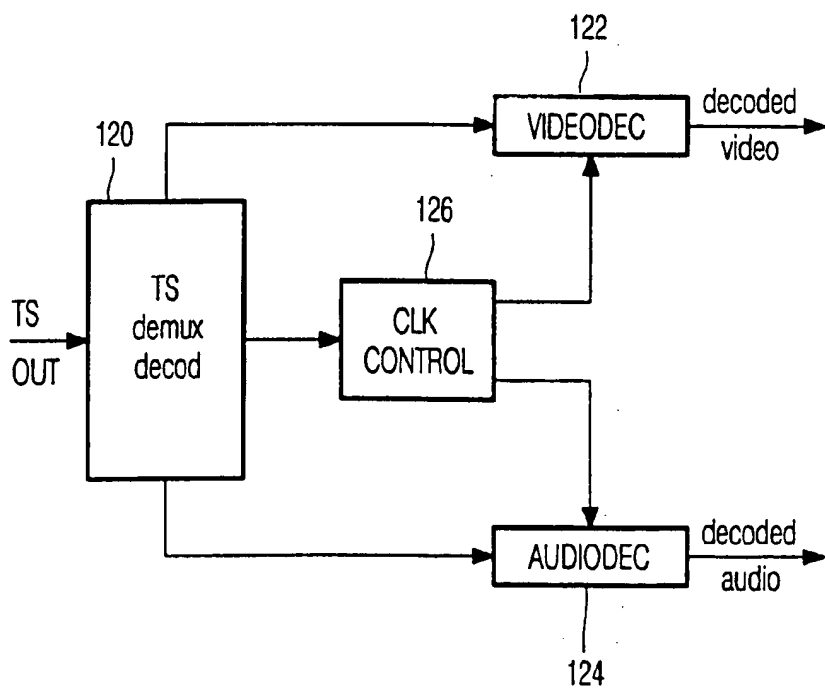
FIG. 4

replayins

FIG. 5

FIG. 6

METHOD OF STORING DIGITAL AUDIO AND/OR VIDEO PROGRAMS COMPRESSED ON THE BASIS OF GROUPS OF PICTURES (GOPS) ON A MEDIUM WITH IMMEDIATE JUMPING BETWEEN GROUPS THROUGH CO-STORAGE OF TRANSPORT STREAM PACKETS AND POINTER INFORMATION, A METHOD FOR READING SUCH INFORMATION, AND A DEVICE FOR STORING AND/OR READING SUCH INFORMATION

BACKGROUND OF THE INVENTION

The invention relates to a method as recited in the preamble of claim 1. Classical video recording allows trick modes such as fast forward and fast reverse. Trick modes have become more complex to implement for digital video that is compressed on the basis of groups of pictures (GOP), because uniform video intervals may correspond to data packet sequences of non-uniform lengths, depending on the information content of the video. U.S. Pat. No. 5,701,386 allows fast forward and fast reverse by providing each Group of Pictures with a GOP header and each sequence of GOPs with sequence headers both before its first GOP and also before its last GOP. Hereinafter, the term "picture" will be used consistently. Depending on the actual video standard, the term "picture" may include "frame" as well as "field". However, modern digital broadcast, in particular via satellite, uses Transport Streams (TS) according to system layer standard ISO/IEC 13818-1 for transmitting multi-channel audio and/or video. The video layer standard may be H262 or ISO/IEC 13818-2, the audio layer standard ISO/IEC 13818-3. These features are used inter alia for DVB and are intended for linear play without feedback from a decoder. Packets arrive at a receiver one by one and their assignment to a particular program is generally not known, before the packet itself will have arrived: indeed, assignment is through PSI-tables. For storage, one or more specific programs are selected from a received Transport Stream. This will necessitate either at storing time or at replay time the adapting of certain stream parameters for retaining a valid Transport Stream for replay.

Replay systems will generally support jumping over a selectable physical storage distance, but the probability of then hitting an entry point to the actually stored program is low. The finding of such entry points will necessitate repeated and time intensive searches, which may cause buffer underflow. It also becomes nearly impossible to replay the stream at an n times higher speed with n integer, as well as to land immediately on a video fragment that may be played independently. Therefore, if storage takes place on a dedicated apparatus, the locations of the entry points must be immediately known, either directly, or via pointers. The problem becomes more severe if a plurality of program must be stored.

SUMMARY TO THE INVENTION

In consequence, amongst other things, it is an object of the present invention to format stored video in such manner that various trick modes will become feasible for a Transport Stream environment, whilst maintaining the data handling facilities proper to this environment.

Now therefore, according to one of its aspects the invention is characterized according to the characterizing part of claim 1. The invention also relates to a method for replaying such recorded Transport Stream and to a device arranged for practising the invention. Further advantageous aspects of the invention are recited in dependent Claims.

BRIEF DESCRIPTION OF THE DRAWING

These and further aspects and advantages of the invention will be discussed more in detail hereinafter with reference to the disclosure of preferred embodiments, and in particular with reference to the appended Figures that show:

FIG. 1, a block diagram of a recording organization;

FIG. 2, a diagram of a Transport Stream structure;

FIG. 3, a diagram of the stored data structure;

FIG. 4, a block diagram of a replaying organization;

FIG. 5, packaging a Transport Stream;

FIG. 6, unpackaging a Transport Stream.

STRUCTURAL DESCRIPTION OF A RELEVANT ENVIRONMENT

According to their agreed upon format, Transport Stream Packets start with a Transport Stream packet header, which contains a Packet IDentifier PID. Through the Program Specific Information PSI tables, the data content in a TS packet will be known. The PID for the video data V_PID of each transmitted program is stored in the PSI tables in the Transport Stream. A variable payload_unit_start_indicator pusi is stored in the Transport Stream packet header and indicates whether the payload of the packet in question starts indeed with the first byte of a Packetized Elementary Stream PES packet (ISO/IEC standards supra). Finally, the adaptation_field_control (afc) indicates whether the Transport Stream packet contains indeed an adaptation field and/or a payload.

To set a pointer, the system usually only needs to access packets that have PID=V_PID, pusi=1 and an afc that is either equal to 1 or equal to 3. If the table would be too long for a single 188 byte packet, two or more contiguous packets with PID=V_PID must be accessed. Only packets so signalled need be checked for presence of an entry point. Entry points may be as follows:

a TS packet with the start of an I-picture;

a TS packet with the start of a GOP;

a TS packet with the start of a sequence header.

The pointers may be transiently stored in RAM memory and eventually written to disc. A program with a video take length of 135 minutes with 25 pictures per second, a 12-picture GOP size and a pointer length of 4 bytes, will produce about 0.54 Mbit or 67 kByte pointer information. At a 16 Mbaud transfer speed, writing all pointers this will need about 35 millisecs, provided they get a separate disc area. If RAM is too small, the pointers must be written earlier. The pointers may be kept within the stored stream, such as by storing them when reaching a certain number such as 1000 selected packets. At replay, pointer positions will then be known immediately. Alternatively, a table of pointer locations may be used. If the pointers are kept on a separate location, they may be written either after a certain time interval, or at instants when actual bitrate is low, or anyway before reaching buffer storage capacity.

The following further information may be stored with the pointers to facilitate the replay of a stored program:

the length in seconds of the video at recording time to calculating the remaining time;

size of the GOPs, and if applicable, the characterization of the GOPs as being closed or non-closed, such as according to MPEG-standard, and whether their sizes are uniform or not;

3

4

the PID of packets containing the Program Map Table PMT;

the PID of packets storing the Program Clock Reference PCR;

the PID of packets with video information;

Start Time Code that may be used to calculate elapsed time;

Frame Rate that in combination with a uniform GOP size may be used to jump to a particular instant in time;

the total number of TS packages which may be used to calculate the end of the program in question;

the overall numbers of I-, B- and P-pictures;

the total number of I-pictures;

average bitrate.

The use of Pointers may support replaying of a particular program at higher speed. Transport Stream conditions should be maintained by avoiding referencing non-existent pictures. Further, certain fields may have to be adapted.

Trick play is facilitated by forwarding to a decoder only TS packets that contain video information, inclusive of SI information and PCR packets. Faster play of sound is generally not useful. The storing of extra information will allow to select for forwarding exclusively those packets that have a PID corresponding to that of PAT, PMT, PCR, and V_PID. The GOP size information may be used for in a "non-closed" GOP environment, during replay of complete GOP's, selectably bypassing a particular B-picture, and possibly to adapt temporal references in other packages. The video duration at recording time may be used, in combination with the time code stored in the GOP header to calculate and display elapsed time. The combination of frame rate and a fixed GOP size allows to periodically replay exactly a specified number of seconds, and to subsequently jump n times the earlier number, where n may have values such as in the range 1–100. An extra advantage of pointer-supported storage is that a program need to be stored only once. The described organization supports the recording of a plurality of programs in parallel in the secondary Transport Stream in an interleaved manner. In that case, each program will need its associated array of pointers.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 is a block diagram of an exemplary recording organization. Input 20 receives a Transport Stream. In block 22, selection of the required TS packets and time stamp insertion take place, followed by storing in Stream Info Memory 24. In block 26, the selected TS packets are counted, and the count actually attained is forwarded to Pointer Info Memory 28. In block 32, entry points are extracted, and counted in block 30: the count is forwarded both to Pointer Info Memory 28 and to Stream Info Memory 36 that is in fact the same as block 24. In block 34, the Time Code is retrieved from the GOP header and if its value is zero, any necessary modification may be effected. In block 38, the Start Time Code is extracted for forwarding to the Stream Info Memory. In block 40, the GOP size and Picture Rate informations are extracted and forwarded to Stream Info Memory, now block 50. In block 42, the Closed GOP Indicator is extracted, in block 44 the PCR_PID, in block 46 the PMT_PID, and in block 48 the video PID, all for forwarding to the Stream Info Memory 50. The information on output 49 is ready for being stored. The Figure does not specify the mapping of various partial functionalities on proper hardware, which may be realized as conventional mechanisms that have not been shown for brevity.

FIG. 2 is a diagrammatical embodiment of the Transport Stream structure. Here, the uppermost level shows the sequence of Transport Stream Packets that each contain 188

bytes. On the next level a packet consists of a 4-Byte header that accommodates at least the informations PID, pusi and afc. The remainder is the TS-packet data. On the third level the data field may contain an adaptation field and/or a payload field that are sized according to need, and may be internally specified through the afc information.

FIG. 3 is a diagram of the stored data structure. Block 64 symbolizes the stream information formed by TS packets containing all information that has been selected on the basis of the information stream received on input 22 in FIG. 1. Block 62 symbolizes the pointer information that has been produced by blocks 26, 30, 32 in FIG. 1. Block 60 symbolizes the stream information produced by the various blocks in FIG. 1, such as in particular blocks 22, 30, 38, 40, 42, 44, 46 and 48. Now, first the informations from blocks 60 and 62 are combined for contiguous storage. Next, the compound so formed, as well as the informations from block 64 are stored on the medium. The latter informations may be stored in physically distant locations from the former: the linking is through the file system. The overall information is collectively stored on disc in a format that may be configured along the exemplary teachings of FIG. 2. During a program, TS packets will be written continually. Pointer and stream informations are being written either after termination of the video take, or in relatively small-sized amounts during the video take.

FIG. 4 is a block diagram of an exemplary replaying organization. Item 70 represents the rewritable storage disc together with its associated electromechanical, electro-optical and electronic components for driving and information accessing, inclusive of demodulation, error correction and similar features that operate on a relatively lower organizational level than the present invention. Block 72 executes demultiplexing into three sub-streams. Block 74 symbolizes the Pointer Info Memory substream. Block 76 symbolizes the Stream Info Memory substream. These two streams are forwarded to control unit 80 that may execute the following user control functions:

setting the disc replay velocity, such as 1 ... n times normal speed;

optionally, setting the minimum play duration before effecting a jump; here, various possibilities exist, such as play n GOPS before a jump, jump speed xn GOPs, or: play an I-picture, repeat n times, then jump to the next I-picture, etcetera;

if a plurality of programs had been stored: program select;

setting the video start position where to start playing the program in question from;

play/record;

stop;

goto a specified point in time;

fast forward & fast reverse.

Control functions are for example as follows:

display actually elapsed time from the start of the program that is being read out;

retrieving pointer and stream information from disc;

control goto operations to specific byte positions such as to access an entry point;

play as starting from a specified physical location;

record unto a specified physical location.

The control unit may forward signals so developed along control lines 92, 94, 96, 98 to various subsystems to be identified hereinafter. First, the disc-oriented subsystem 70 is controlled along line 92. The Transport Stream demultiplexed from block 72 is forwarded to block 82 for extracting of the time code. Block 84 detects whether the indicator Closed-GOP is false (=1) and play n GOPs, replace first

B-picture packets with null packets. Furthermore, block **84** detects whether the indicator Closed-GOP is false (≠1), or play I-pictures only, update continuity counter in the TS packet header, update temporal reference in picture header, and set broken link in GOP header to 1, the latter depending on the decoder type.

Block **86** detects whether replay speed ≠1, and in the positive case replaces all TS packets, except Video PID packets, PCR PID packets, PMT PID packets and PAT PID(0) packets with null packets. Furthermore, Presentation Time Stamp, Decoding Time Stamp, and PCR numbers are modified to reflect the correct presentation and decoding times.

Block **88** detects whether there are timestamps or not; in the positive case, the Time Base is reconstructed and the Time Stamps removed. Output **90** will present an amended Transport Stream according to the MPEG-2 standard. For brevity, the Figure does not specify mapping various partial functionalities on hardware.

A particular aspect of a Transport Stream is that all TS packets will start with a TS Header that contains a PID.

FIG. 5 illustrates the packaging of a Transport Stream. At left, both video data and audio data arrive at their respective encoders **110** and **112**. Both encoders then feed respective packetizers **112** and **116**, respectively to produce a stream of video PES and a stream of audio PES. In multiplexer **118**, the two streams are multiplexed to constitute an input Transport Stream that is ready for storage.

FIG. 6 illustrates unpackaging a Transport Stream. At left, a compound Transport Stream enters a demultiplexer annex decoder **120**, that will separate video from audio. Block **126** is furthermore operative for clock extraction, and synchronizes video decoder blocks **122** and audio decoder block **124**. The decoded video and audio informations are then available for consumer replay.

Various relevant aspects of the invention are as follows:

The elapsed time indicator may be retrieved from the GOP-header and the Start Time Code and is independent from bitrate and GOP-size;

Fast forward and fast reverse are feasible at any speed, even if a single disc contains more programs in a physically, but not logically intermixed manner;

Both the pointer table and the TS information may be stored on an arbitrary disc location. There is some kind of Table Of Contents that for all programs contains starting locations of the TS packets/program, of the pointer tables and of the TS information tables.

Trick play requires no extra regrouping or reformatting of the picture sequences;

External as well as an internal decoders may be used;

No explicit sector argument needed for TS-packets containing an entry point;

Data need not be stored in a physically contiguous manner;

Interleaved storage of audio, video and other data is allowed;

The invention allows all GOP-sizes, even non-uniform GOP-sizes.

What is claimed is:

1. A method for recording one or more digital audio and/or video programs that have been compressed on the basis of groups of pictures (GOPs), on a medium that allows

immediate jumping between groups through co-storage of Transport Stream packets and pointer information,

characterized by coexistently with said storing, in real-time deriving from a primary Transport Stream successive pointers that collectively point to data packets in a secondary Transport Stream that contains entry points, and which pointers are stored at predetermined locations on said medium.

2. A method as claimed in claim 1, wherein said predetermined locations are within said secondary Transport Stream.

3. A method as claimed in claim 1, wherein said predetermined locations are in a Table area outside said secondary Transport Stream.

4. A method as claimed in claim 1, for use with a plurality of interleaved programs in said secondary stream, whilst providing each such program with a privy array of pointers.

5. A method as claimed in claim 1, furthermore indicating a size of the GOPs, and if applicable, a characterization of the GOPs as being closed or non-closed, and whether their sizes are uniform or not.

6. A method as claimed in claim 1, furthermore indicating a PID of a packet containing a Program Map Table.

7. A method as claimed in claim 1, furthermore indicating a PID of a packet containing a Program Clock Reference.

8. A method as claimed in claim 1, furthermore indicating a PID of a packet that contains video information.

9. A method as claimed in claim 1, furthermore indicating a Start Time Code to be used to calculate elapsed time.

10. A method as claimed in claim 1, furthermore indicating a Frame Rate to be used in combination with a uniform GOP size to jump to a particular instant in time.

11. A method for replaying one or more digital audio and/or video programs with coded data that have been compressed on the basis of groups of pictures (GOPs), from a medium that allows immediate jumping between groups through stored Transport Stream packets and pointer information,

characterized by accessing in an individual or compound Transport Stream being replayed, in realtime successive pointers that collectively point to data packets in a particular individual Transport Stream that contains entry points, by accessing such pointers at predetermined locations on said medium.

12. A method as claimed in claim 11, wherein said predetermined locations are within said secondary stream.

13. A method as claimed in claim 11, wherein said predetermined locations are in a Table area outside said secondary stream.

14. A method as claimed in claim 11, furthermore retrieving a Frame Rate indication for use in combination with a uniform GOP size to jump to a particular instant in time.

15. A recording device arranged for practising a method as claimed in claim 1.

16. A replay device arranged for interfacing to information that has been recorded according to a method as claimed in claim 1.

17. A device as claimed in claim 15, and arranged for interfacing to a rewritable disc.

*   *   *   *   *